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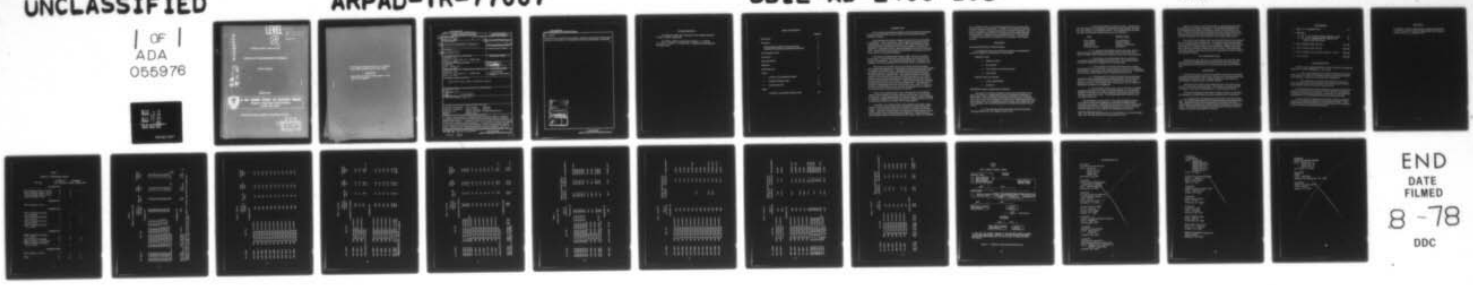

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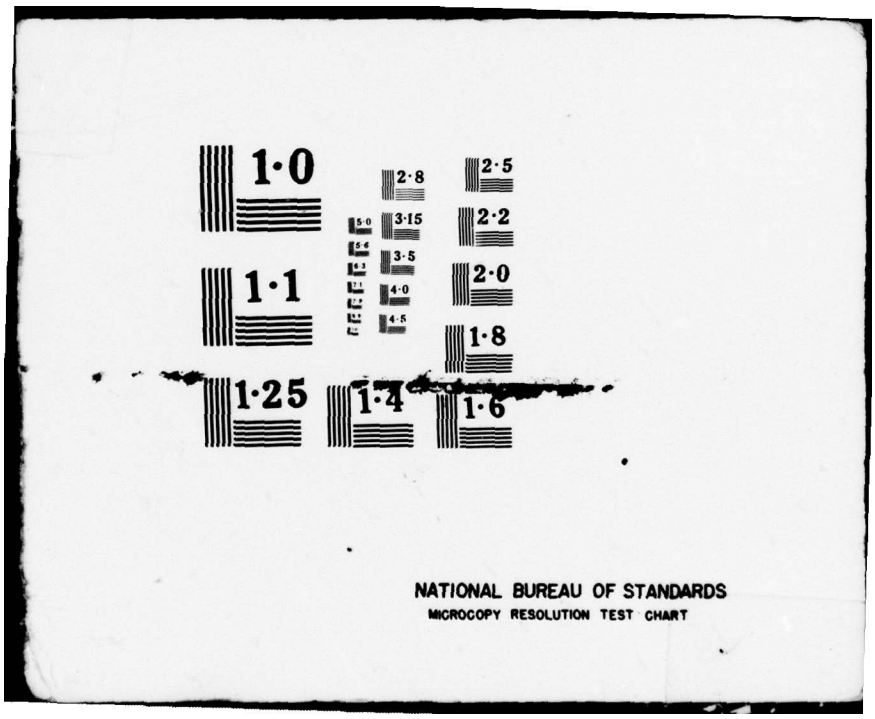
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NATIONAL BUREAU OF STANDARDS
MICROCOPY RESOLUTION TEST CHART

LEVEL II

TECHNICAL REPORT ARPAD-TR-77007

PROPELLANT REASSESSMENT PROGRAM

GAYTON SILVESTRO

MARCH 1978

US ARMY ARMAMENT RESEARCH AND DEVELOPMENT COMMAND
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Propellant surveillance	Percent stabilizer	Reliability
Laboratory test	Relative quickness	Storage characteristics
Moisture	Relative force	

20. ABSTRACT (Continue on reverse side if necessary and identify by block number)

As part of the Ammunition Stockpile Reliability Program (ASRP), a number of stockpiled propellant lots were reassessed for end-item use under the Propellant Reassessment Program. A sequence of laboratory and ballistic testing was developed to aid in the evaluation of these propellants. The evaluations were made with respect to the safety and performance of the propellant. Based on the propellant reassessments, disposition of 46 stockpiled propellant lots was recommended. Storage controls were developed for incorporation into the propellant stockpile system. As a

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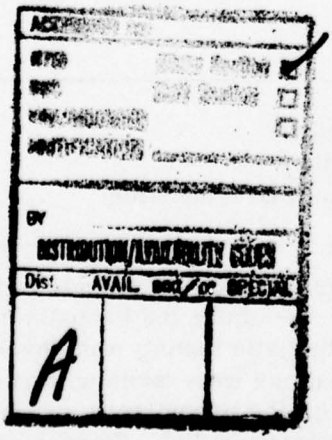
result of the first 18 months of the program, propellant reassessments have directly provided a cost avoidance, in ballistic test costs for the Government, of $384,000.



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INTRODUCTION

The Propellant Reassessment Program and the Propellant Surveillance Program were developed as sub-activities of the Ammunition Stockpile Reliability Program.

The Propellant Surveillance Program deals primarily with the safety of propellants. Under the program, master samples of propellants stored at ARRADCOM are periodically evaluated for their stability characteristics. Using the stability characteristics of the master samples as a baseline for comparison, propellants stored at depots throughout the world are also evaluated. The evaluation of its stability characteristics are the basis for accurate prediction of a propellant's safelife.

The Propellant Reassessment Program (PRP), which is the subject of this report, is concerned not only with the safety but also with the performance of propellants. This program involved the test, evaluation, and disposition of stored propellants for which there may be an immediate need.

Until now under the PRP, there was no official technical document that controlled the disposition of propellant lots whose storage period exceeded the loading authorization limits. The propellant acceptance sheets for bulk propellants note only a loading authorization date that expires nominally five years after the acceptance date. This command conducted a thorough search in 1974 to discover the source of the five-year period, but no documentation could be found that specifically established the five-year period. It was noted that MIL-STD-1171 states"---enter the month and year (normally five years from the date of the most recent assessment)." But since the rationale for establishing the five-year time frame is not a matter of record, it can only be assumed that the (then) 20-year life expectancy of a propellant lot was arbitrarily divided into quarter-life periods.

From a more scientific point of view, the chemistry of the stabilizer content of the propellant is directly related to the time span of the loading authorization. Under the Propellant Surveillance Program, extensive testing is conducted at ARRADCOM to make sure that the stabilizer content of all lots of propellant conforms to the safety limits of the propellant.

In addition, the volatile content of the propellant has become a major concern in recent years because of the increased use of fiber storage containers. The use of fiber containers can result in a change in the volatile content. (Note that "volatile content" as used here includes moisture as well as the solvents used in manufacturing the propellant.) Recent laboratory tests of M26E1 propellant demonstrated that the volatile content of a propellant

has a significant affect on its relative quickness and may, in turn, significantly change its performance. Therefore, when propellant reassessments are conducted, storage controls such as the type of container, the type of propellant, and the period of storage are all extremely important considerations in obtaining valid reassessment results. The time limits on loading authorizations for propellants are contingent on the storage controls.

DISCUSSION

Recommended Propellant Testing Sequence

A recommended sequence of testing for propellant reassessment to certify the usability of the propellant is listed below.

Laboratory Tests

1. Stabilizer content
2. Heat stability
3. Total volatiles (including moisture)
4. Closed bomb

Ballistic Tests (as required)

1. Charge establishment
2. Uniformity

ARRADCOM Propellant Reassessment Guidelines

Since there is no official document that provides procedures for propellant reassessment, ARRADCOM developed reassessment guidelines as stated below. They are based on experience in making lot-by-lot dispositions, and cover all bulk propellants in CONUS and overseas storage locations. The guidelines also cover propellants stored in metal, metal-lined wood, and fiber containers; and, propelling charges and propellant increments stored in bulk.

a. For lots stored in metal and metal-lined wood containers (drawing numbers 76-4-46, 7549033, and 76-4-56):

1. If the storage interval exceeds five years, chemical tests (MIL-STD-652C) will be performed to determine the total volatiles, total moisture, heat stability, and stabilizer content. If the propellant fails the chemical tests, the following remedial actions must be considered.

Test	Remedial Action
Total volatiles	Drying treatment
Total moisture	Drying treatment
Heat stability	Reblend or demilitarize
Stabilizer content	Demilitarize

2. If, except for the stabilizer content (see note), the propellant meets the requirements of the chemical tests, closed bomb tests (MIL-STD-286B) will be performed to determine relative force and quickness.

3. If the results of the closed bomb tests are satisfactory (no significant statistical change since the last test), the loading authorization will be certified for continued use for five more years.

4. If the propellant lot fails the closed bomb tests (significantly different from the last test), the test results for the lot will be referred to ARRADCOM. Depending on the interpretation of laboratory tests, ARRADCOM will recommend either ballistic tests or demilitarization of the lot.

5. If the propellant lot meets the ballistic test requirements (propellant charge establishment and uniformity series), the lot will be certified for use and the loading authorization extended for five more years. However, if the lot fails the ballistic test, the test results will be referred to ARRADCOM to determine its disposition.

b. For lots stored in fiber drums, and for M5, M26, and M26E1 propellants regardless of the type of storage containers, the reassessment procedure is the same as in a above except that the storage interval will be two years instead of five years. The loading authorization extension time will also be two years.

The guidelines in a and b above, shown diagramatically in figure 1, were used to evaluate the propellant lots reassessed by ARRADCOM as described in this report. The guidelines are to be used for the reassessment of all propellant lots; they are being incorporated in a revision of SB 742-1300-94-2 which covers surveillance and reassessment procedures.

Note: The stabilizer content must be at a level suitable for continued storage. This value is at least 50 percent of the specification value.

Table 1 is a summary of the 46 propellant lot reassessments performed during the first 18 months of the program. The loading authorizations for the 32 acceptable lots (based on laboratory testing) were extended for five years. Fourteen lots failed the closed bomb tests and required ballistic tests. Subsequently, the ballistic tests established new charge weights and the 14 lots were accepted for five-year extensions of the loading authorizations.

The results of the chemical tests and closed bomb tests on the reassessed lots are in tables 2 and 3, respectively. The chemical test results show that each lot met specification requirements (no significant change in heat stability, total volatiles, or stabilizer content since manufacture) despite the fact that some of the lots have been in storage from 20 to 25 years. The closed bomb test results (table 3) show that 32 lots met the requirements and were accepted without further testing.

TEST PROCEDURES USED

Chemical tests (MIL-STD-652) and closed bomb tests (MIL-STD-286) were performed at ARRADCOM in accordance with the military standards. The ballistic tests were performed in accordance with appropriate specifications.

CONCLUSIONS

The effect of long-term storage on propellants tested to date is minimal. Propellants that had been stored for up to 25 years were still chemically stable and performed according to their original specification requirements for heat stability, stabilizer content, and total volatiles.

According to the results of the closed bomb tests, the relative quickness of 14 (out of 46) lots had changed. This change is related to the type of propellant, the type of storage container, and the storage locations.

The type of propellant and the type of storage container are the important parameters in determining how long a propellant may be reassessed.

If a reassessed lot of propellant passes the chemical and closed bomb tests, the loading authorization may be extended without conducting ballistic tests. Since the 32 lots of the 46 reassessed to date passed these tests, a considerable cost avoidance for ballistic testing was realized as summarized below. Note that similar savings may also be realized on future lots of propellants reassessed as discussed in this study.

Cost Summary

1.	**Total no. of reassessed lots**	46
2.	**Disposition**	
	A. No. of lots accepted (passed laboratory tests)	32
	B. No. of lots recommended for Ballistic test (failed closed bomb tests)	14
3.	**Cost of Ballistic tests (per lot)**	$12,000
4.	Cost of Ballistic tests (46 lots)	$552,000
5.	Cost of Ballistic tests (actually required, 14 lots)	$168,000
6.	Cost avoidance	$384,000

RECOMMENDATIONS

Based on past experience factors and the Propellant Reassessment Program test results highlighted in this report:

1. The 5-year storage interval between propellant lot reassessments should be retained for propellants stored in metal and metal-lined wood containers (except for some double-base propellants).

2. For propellant lots stored in fiber containers and for M5, M26, and M26E1 double-base propellants, the storage interval between reassessments should be two years (instead of five).

The propellant reassessment procedures developed by ARRADCOM should be incorporated in a revision of SB-742-1300-94-2 covering surveillance and reassessment procedures. This action will provide official documentation for the Propellant Reassessment Program activities.

A yearly report on propellant reassessments should be published to summarize information obtained on the propellant stockpile. These reports would provide the basis for any future changes in the storage intervals directed by the loading authorizations.

REFERENCE

G. Silvestro, "Storage Characteristics of M26E1 Propellant for 152 MM Ammunition," Technical Memorandum 2208, Picatinny Arsenal, Dover, NJ, September 1976

Table 1

Summary of reassessment results

End item	Number of lots reassessed	Disposition: Accept	Disposition: Ballistic test
Propellant M1			
M67 Propelling charge, 105 mm	6	5	1
M4A1 Propelling charge, 155 mm	3	3	
T119 Propelling charge, 90 mm	1	1	
M71A1 Cartridge, 90 mm	1	1	
Propellant M5			
M371 Cartridge, 90 mm	1		1
Propellant M8			
M1A1 Propelling increment, 81 mm mortar	8	7	1
M2A1 Propelling increment, 81 mm mortar	2		2
M3A1 Propelling increment, 60 mm mortar	2	1	1
M36A1 Propelling Incremnt, 4.2" mortar	2	2	
Propellant M9			
M36A1 Propelling increment, 4.2" mortar	5	2	3
M3 & M6 Ignition cartridge	5	2	3
M362 Cartridge, 81 mm mortar	1		1
M90A1 Propelling increment, 81 mm mortar	7	7	
Propellant M30A1			
M121 Cartridge, 105 mm	2	1	1
Totals	46	32	14

Table 2

Results of chemical tests

Lot number	End item	Year of manufacture /storage	Heat test (min)	Total volatiles (%)	Stabilizer content (%)
	Propellant M1				
RAD 67720	M67 Propelling charge, 105 mm	1969	55	1.11	0.97
RAD 66556	M67 Propelling charge, 105 mm	1969	60	0.83	0.90
RAD 66491	M67 Propelling charge, 105 mm	1968	60	1.00	1.03
RAD 66603	M67 Propelling charge, 105 mm	1968	50	0.95	1.08
RAD 67525	M67 Propelling charge, 105 mm	1969	65	1.13	0.97
RAD 67554	M67 Propelling charge, 105 mm	1969	50	1.02	0.97
BAJ 63419	M4A1 Propelling charge, 155 mm	1955	80	1.21	0.89
RAD 60406	M4A1 Propelling charge, 155 mm	1955	80	1.07	0.92
RAD 60532	M4A1 Propelling charge, 155 mm	1955	80	0.99	0.87
IAB 38828	T119 Propelling charge, 90 mm	1952	55	0.86	0.70*
RAD 60402	M71A1 Cartridge, 90 mm	1966	85	0.88	0.96
Requirements for M1 Propellant			40	1.0 ± .20	1.0 + .20 -.20
	Propellant M5				
RAD 64592	M371 Cartridge, 90 mm	1966	105	0.81	0.64
Requirements for M5 Propellant			40	2.89 max	0.60 ± .15

*Stabilizer content of control lots that went into this reblend, indicates that this lot be loaded into ammunition and exhausted within a five year period.

Table 2 (Cont'd)

Lot number	End item	Year of manufacture /storage	Heat test (min)	Total volatiles (%)	Stabilizer content (%)
		Propellant M8			
RAD 33947	M1A1 Propelling increment, 81 mm mortar	1953	80	0.26	0.66
RAD 33972	M1A1 Propelling increment, 81 mm mortar	1953	80	0.23	0.67
RAD 36985	M1A1 Propelling increment, 81 mm mortar	1954	80	0.24	0.66
RAD 38386	M1A1 Propelling increment, 81 mm mortar	1953	70	0.24	0.59
RAD 65001	M1A1 Propelling increment, 81 mm mortar	1966	90	0.30	0.59
RAD 68089	M1A1 Propelling increment, 81 mm mortar	1970	80	0.14	0.62
RAD 64661	M1A1 Propelling increment, 81 mm mortar	1964	75	0.16	0.57
RAD 65152	M1A1 Propelling increment, 81 mm mortar	1966	60	0.32	0.54
RAD 66538	M2A1 Propelling increment, 81 mm mortar	1969	55	0.21	0.63
RAD 66537	M2A1 Propelling increment, 81 mm mortar	1969	65	0.31	0.63
RAD 64846	M3A1 Propelling increment, 60 mm mortar	1966	65	0.23	0.63

Table 2 (Cont'd)

Lot number	End item	Year of manufacture /storage	Heat test (min)	Total volatiles (%)	Stabilizer content (%)
	Propellant M8 (Cont'd)				
RAD 65005	M3A1 Propelling increment, 60 mm mortar	1966	65	0.19	0.63
RAD 68321	M36A1 Propelling increment, 4.2" mortar	1971	75	0.22	0.60
RAD 60276	M36A1 Propelling increment, 4.2" mortar	1973	75	0.28	0.62
Requirements for M8 Propellant			40	0.40	0.60 ± .15
	Propellant M9				
RAD 66567	M36A1 Propelling increment, 4.2" mortar	1968	60	0.30	0.76
HEP 68785	M36A1 Propelling increment, 4.2" mortar	1972	65	0.32	0.79
CIL 68380	M36A1 Propelling increment, 4.2" mortar	1971	65	0.35	0.81
CIL 68381	M36A1 Propelling increment, 4.2" mortar	1971	65	0.34	0.83
CIL 69122	M36A1 Propelling increment, 4.2" mortar	1973	65	0.43	0.76
HEP 39603	M3 & M6 Ignition cartridge	1954	70	0.50	1.22*
HEP 64253	M3 & M6 Ignition cartridge	1957	60	0.47	00.84

*Manufactured with 1.30% EC (modified).

Table 2 (Cont'd)

Lot number	End item	Year of manufacture /storage	Heat test (min)	Total volatiles (%)	Stabilizer content (%)
		Propellant M9 (Cont'd)			
RAD 64447	M3 & M6 Ignition cartridge	1962	70	0.22	0.79
HEP 64175	M3 & M6 Ignition cartridge	1957	75	0.50	0.82
HEP 64174	M3 & M6 Ignition cartridge	1957	55	0.40	0.81
RAD 64744	M362 Cartridge, 81 mm mortar	1965	70	0.29	0.69
CIL 68519	M90A1 Propelling increment, 81 mm mortar	1972	65	0.48	0.75
CIL 68540	M90A1 Propelling increment, 81 mm mortar	1972	55	0.48	0.75
CIL 68526	M90A1 Propelling increment, 81 mm mortar	1972	60	0.50	0.81
CIL 68527	M90A1 Propelling increment, 81 mm mortar	1972	60	0.50	0.80
HEP 67279	M90A1 Propelling increment, 81 mm mortar	1971	55	0.44	0.79
CIL 69100	M90A1 Propelling increment, 81 mm mortar	1973	70	0.32	0.72
CIL 68517	M90A1 Propelling increment 81 mm mortar	1972	70	0.32	0.75
Requirements for M9 Propellant			40	0.50	0.75 ± .10
		Propellant M30A1			
RAD 67187	XM121 Cartridge, 105 mm	1969	130	0.32	1.52
RAD 67186	XM121 Cartridge, 105 mm	1969	145	0.18	1.48
Requirements for M30A1 Propellant			40	0.50	1.50 ± .10

Table 3

Closed bomb tests

Lot number	End item	Year of manufacture	Relative quickness percent At time of manufacture	At time of reassessment	Recommendation
		Propellant M1			
RAD 67220	M67 Propelling charge, 105 mm	1969	106.8	112.4	Ballistic test
RAD 66556	M67 Propelling charge, 105 mm	1969	111.5	112.2	Accept
RAD 66491	M67 Propelling charge, 105 mm	1968	106.6	107.7	Accept
RAD 66603	M67 Propelling charge, 105 mm	1968	105.8	106.3	Accept
RAD 67525	M67 Propelling charge, 105 mm	1969	108.2	110.3	Accept
RAD 67554	M67 Propelling charge, 105 mm	1969	110.0	110.4	Accept
BAJ 63419	M4A1 Propelling charge, 155 mm	1955	100.3	101.0	Accept
RAD 60406	M4A1 Propelling charge, 155 mm	1955	106.0	107.7	Accept
RAD 60532	M4A1 Propelling charge, 155 mm	1955	104.6	108.0	Accept
IAB 38828	T119 Propelling charge, 90 mm	1952		105.7	Accept
RAD 60402	M71A1 Cartridge, 90 mm	1966	104.7	108.2	Accept
		Propellant M5			
RAD 64592	M371 Cartridge, 90 mm	1966	96.9	110.9	Ballistic test

Table 3 (Cont'd)

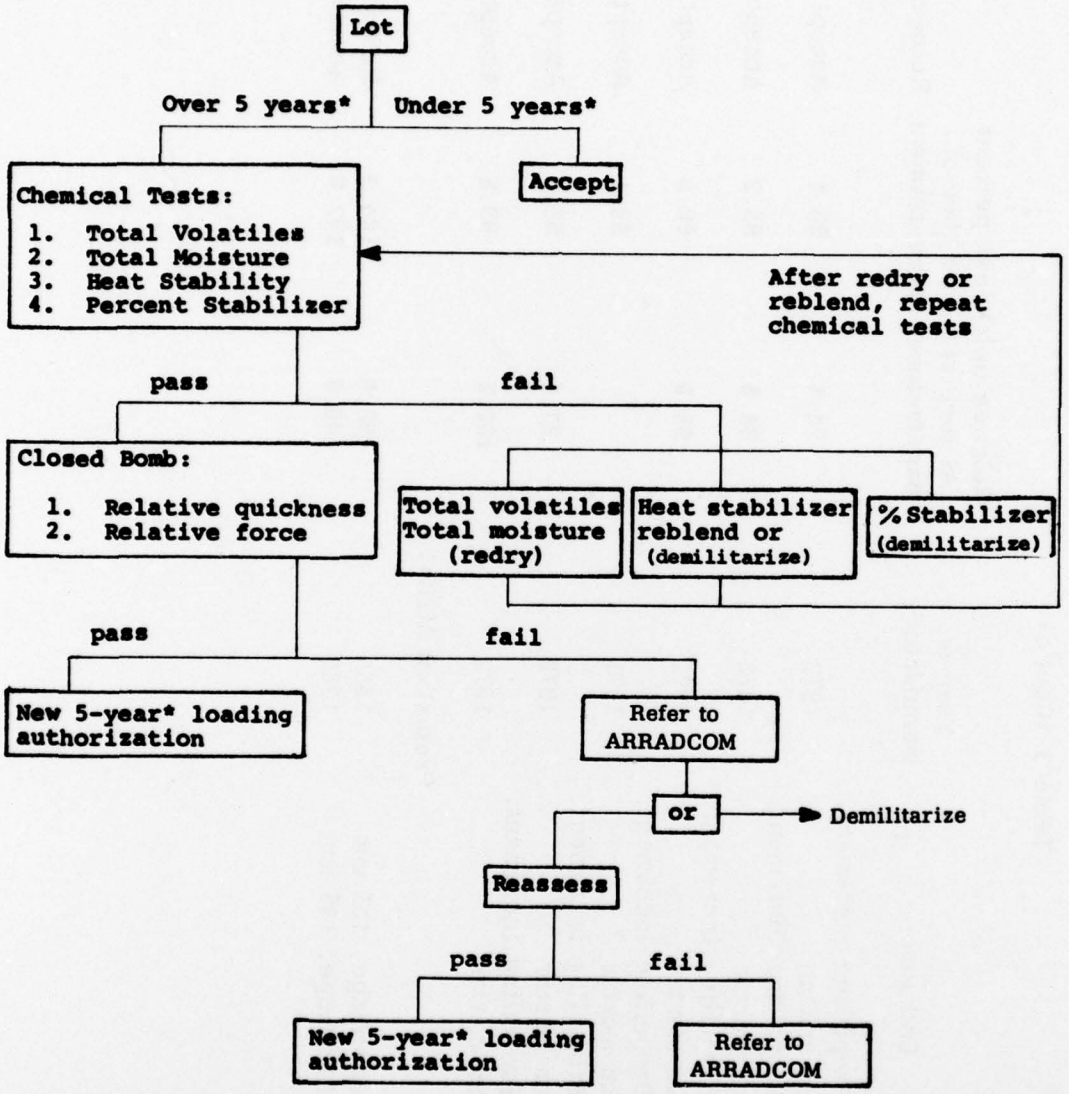
Lot number	End item	Year of manufacture	Relative quickness percent At time of manufacture	Relative quickness percent At time of reassessment	Recommendation
		Propellant M8			
RAD 33947	M1A1 Propelling increment, 81 mm mortar	1953		98.1	Accept
RAD 33972	M1A1 Propelling increment, 81 mm mortar	1953		97.3	Accept
RAD 36985	M1A1 Propelling increment, 81 mm mortar	1954		95.5	Accept
RAD 38386	M1A1 Propelling increment, 81 mm mortar	1953		93.5	Accept
RAD 65001	M1A1 Propelling increment, 81 mm mortar	1966		90.3	Ballistic test
RAD 68089	M1A1 Propelling increment, 81 mm mortar	1970	97.2	94.4	Accept
RAD 64661	M1A1 Propelling increment, 81 mm mortar	1964		98.2	Accept
RAD 65152	M1A1 Propelling increment, 81 mm mortar	1966		99.8	Accept
RAD 66538	M2A1 Propelling increment, 81 mm mortar	1969	105.1	97.1	Ballistic test
RAD 66537	M2A1 Propelling increment, 81 mm mortar	1969	104.3	95.9	Ballistic test
RAD 64846	M3A1 Propelling increment, 60 mm mortar	1966		88.1	Ballistic test
RAD 65005	M3A1 Propelling increment, 60 mm mortar	1966		105.7	Accept

Table 3 (Cont'd)

Lot number	End item	Year of manufacture	Relative quickness percent At time of manufacture	Relative quickness percent At time of reassessment	Recommendation
RAD 68321	M36A1 Propelling increment, 4.2 mm mortar	1971	99.5	97.8	Accept
RAD 60276	M36A1 Propelling increment, 4.2 mm mortar	1953	101.8	97.2	Accept
	Propellant M9				
RAD 66567	M36A1 Propelling increment, 4.2 mm mortar	1968	103.1	113.9	Ballistic test
HEP 68785	M36A1 Propelling increment, 4.2 mm mortar	1972		128.9	Ballistic test
CIL 68380	M36A1 Propelling increment, 4.2 mm mortar	1971	109.0	109.4	Accept
CIL 68381	M36A1 Propelling increment, 4.2 mm mortar	1971	109.9	110.6	Accept
CIL 69122	M36A1 Propelling increment, 4.2 mm mortar	1973	111.1	107.1	Ballistic test
HEP 39603	M3 & M6 Ignition cartridge	1954		111.9	Ballistic test
HEP 64253	M3 & M6 Ignition cartridge	1957		118.1	Ballistic test
RAD 64447	M3 & M6 Ignition cartridge	1962	97.3	92.0	Ballistic test
HEP 64175	M3 & M6 Ignition cartridge	1957		98.7	Accept
HEP 64174	M3 & M6 Ignition cartridge	1957		99.1	Accept
RAD 64744	M362 Cartridge, 81 mm mortar	1965	97.1	92.6	Ballistic test
CIL 68519	M90A1 Propelling increment 81 mm mortar	1972	101.3	100.6	Accept

Table 3 (Cont'd)

Lot number	End item	Year of manufacture	Relative quickness percent At time of manufacture	Relative quickness percent At time of reassessment	Recommendation
CIL 68540	M90A1 Propelling increment, 81 mm mortar	1972	99.8	98.1	Accept
CIL 68526	M90A1 Propelling increment, 81 mm mortar	1972	98.8	95.2	Accept
CIL 68527	M90A1 Propelling increment, 81 mm mortar	1972	99.0	96.0	Accept
HEP 67279	M90A1 Propelling increment, 81 mm mortar	1971		99.1	Accept
CIL 69100	M90A1 Propelling increment, 81 mm mortar	1973	97.4	95.7	Accept
CIL 68517	M90A1 Propelling increment, 81 mm mortar	1972	102.2	99.8	Accept
		Propellant M30A1			
RAD 67187	XM121 Cartridge, 105 mm	1969	98.0	104.3	Ballistic test
RAD 67186	XM121 Cartridge, 105 mm	1969	100.0	102.8	Accept



* Five (5) year interval applies to lots stored in metal or metal-lined wooden containers. However, a two-year interval applies to M5, M26 and M26E1 propellant, as well as any lot stored in fiber containers.

Figure 1. Propellant reassessment decision chart

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